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Linearizing High Power Amplifiers for Modern Communication Systems

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ABSTRACT: *In modern communication system, high power amplifiers are the central component as their function is to amplify the signal and generate the required power for transmission of signals. For this purpose the communication system needs highly linear amplifiers. However with the use of multi carrier and complex modulated signals the response of the amplifier is nonlinear. To make the response of high power amplifiers linear; various linearization techniques are used. This paper presented the review of basic linearization techniques and discussed the advantages and drawbacks of various linearization techniques. In review it is to be noted that among all the linearization techniques pre-distortion technique is the historically one approach for reducing the distortion and make the response almost linear.*

Keywords: High power amplifiers (HPAs), Linearization, Pre-distortion and adaptive linearization.

I. INTRODUCTION:

The rapid growth in technology created a huge demand for highly linear amplifiers. Practically, the response of high power amplifiers is nonlinear. Nowadays modern communication systems make use of multi carrier and complex modulated signals. In both cases, any amplitude or phase distortion of the signal will generate additional undesired signals called *intermodulation distortion products* (IMD) [1]. Because of IMD's beat products are produced in the vicinity of input signals. Although many times these distortion products are very small then the output signal but still may cause interference. Therefore, to compensate these nonlinearities many linearization techniques are used. In this paper, a review

of linearization methods such as feed-forward, feedback and pre-distortion methods are discussed.

II. LINEARIZATION METHODS:

Any systematic method which is used to remove the nonlinear distortion is called linearization. There is a systematic procedure for reducing the distortion; usually an extra component is added to an amplifier, when configured in a box known as linearizer [2]. The choice of linearization method depends upon the various factors like the level of linearity needed, bandwidth required and cost. There are various methods are used to linearize the high power amplifiers. Few of them are presented below:

FEEDFORWARD LINEARIZATION TECHNIQUE:

The feed-forward (FF) technique is invented by Black in 1928. It is the most famous technique to linearize the power amplifiers as shown in figure 1. This technique uses two loop; 1) input signal cancellation loop and 2) distortion cancellation loop. The first loop suppresses the input signal from the output leaving only the error signal. While the distortion cancellation loop suppresses the error component from the output signal. This error signal is amplified by the output signal resulting nearly linear output [3]. This technique is quite complex and some losses create the problem to fully linearize the output.

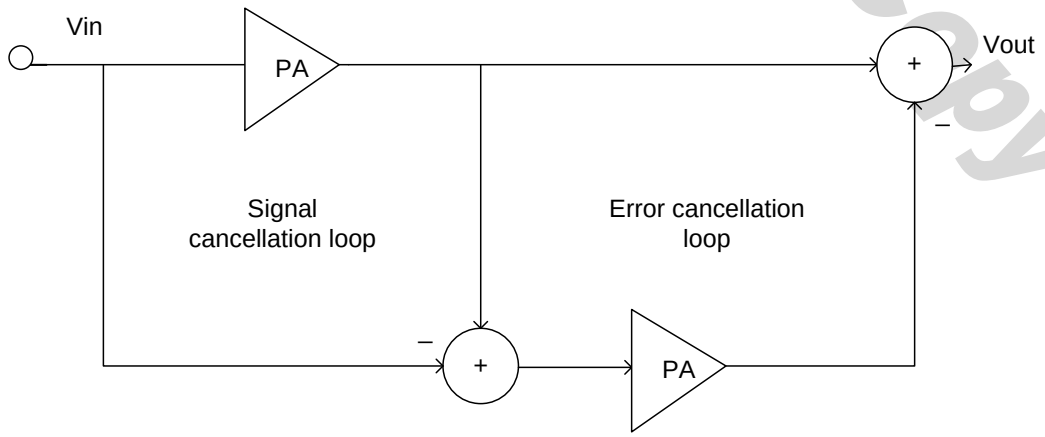

Figure 1: Feed forward linearization [4].

FEEDBACK LINEARIZATION TECHNIQUE:

This technique is also invented by Black. It is very simple and basic technique. In this technique the output of the amplifier fed back to the input [5]. This technique implemented in many ways. The basic diagram for the feedback linearization technique is shown in figure 2. The feedback linearization technique corrected the nonlinearities over a narrowband as band pass filter is used

to limit the frequencies [6]. The main disadvantage of this technique is; it is used for narrow band frequencies, less gain and stability problem.

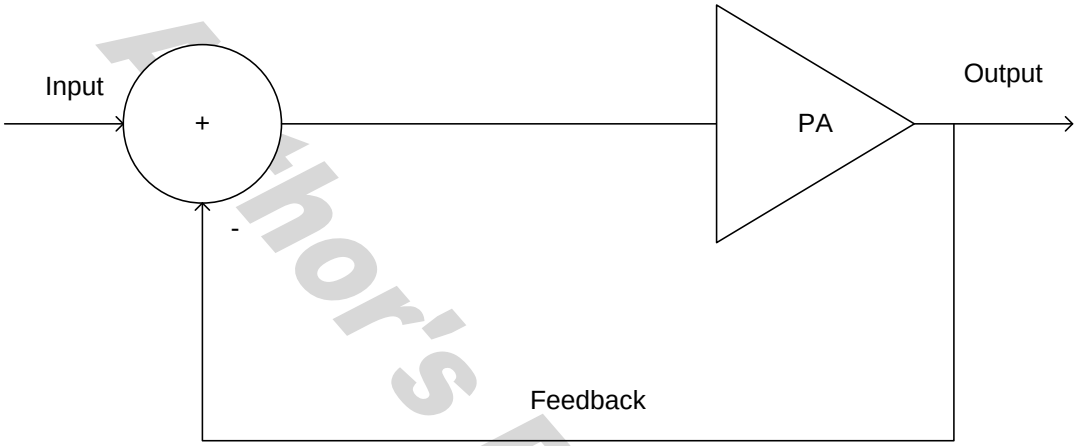

Figure 2: Basic feedback circuit [7].

CARTESIAN FEEDBACK LINEARIZATION TECHNIQUE:

This Cartesian feedback technique separates the input signal into I & Q i.e. in phase and quadrature components [8]. The output of the amplifier demodulated and compare with the input signal gives the error signal. Synchronization is done between the modulator and the demodulator [9]. Due to path differences phase adjuster is necessary as it maintains the relationship in input and feedback signals [10] as shown in figure 3.

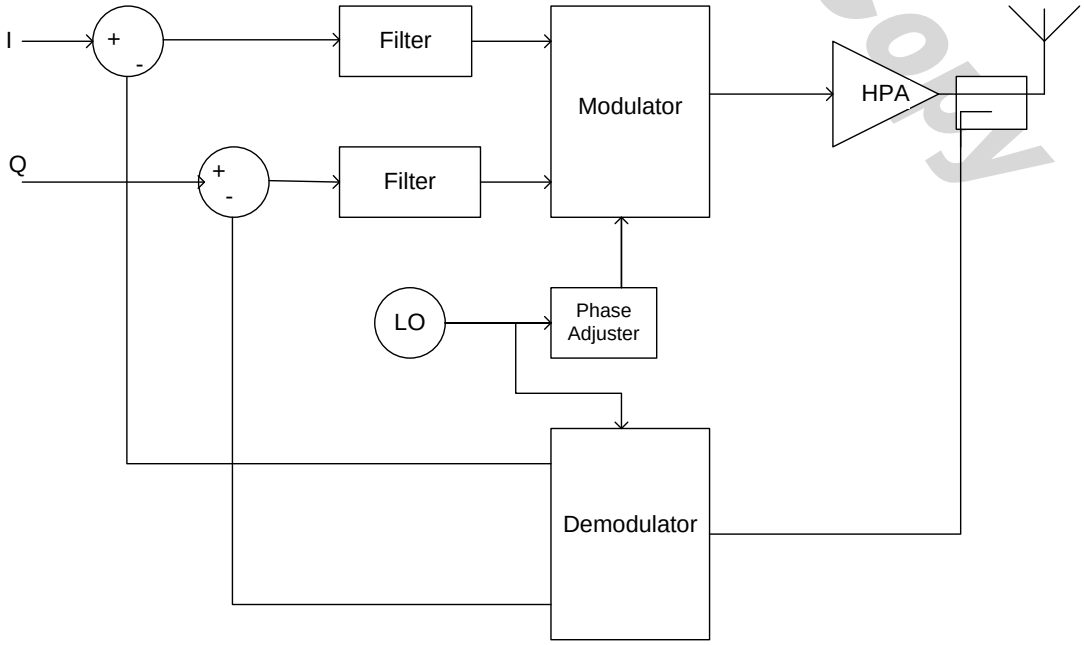

Figure 3: Basic block diagram of Cartesian Feedback [10].

The advantage of this system is that the bandwidths for in-phase and quadrature are same. Although this alternate technique is better than the existing still having some drawback like

delay problem, and it also suffers as misalignment. This technique also limited for wideband frequencies spectrum.

POLAR FEEDBACK LINEARIZATION TECHNIQUE:

This polar feedback is a baseband feedback scheme where envelope and phase operate independently. The signal is split into polar components and compared with their counterparts of the amplifier's output signal. This technique is robust as it corrected both amplitude and phase. This technique provides greater efficiency than the Cartesian feedback linearization technique [8].

PREDISTORTION LINEARIZATION TECHNIQUE:

Pre-distortion technique is the most important technique to linearize the power amplifiers. In this technique linearizer generate the transfer characteristics which are just opposite to the transfer characteristics of the power amplifier [11]. The block diagram for the pre-distortion is given in figure 4:

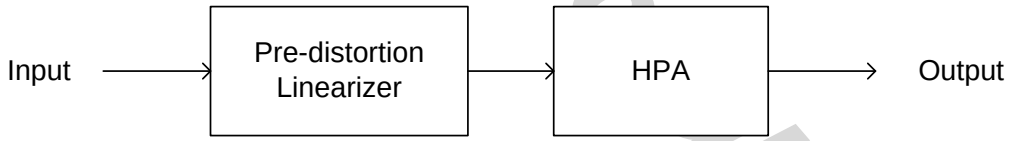

Figure 4: Pre-distortion linearization technique [11].

The pre-distortion techniques have comparatively simple circuitary.it may be classified into two categories; 1) adaptive pre-distortion and 2) non adaptive pre-distortion. The difference between the two categories is very simple. The adaptive pre-distortion estimate the predistorter functions again and again whereas the non-adaptive pre-distortion estimates the pre-distortion function only at one time [12]. That is why adaptive pre-distortion gives the better result. The pre-distortion technique can be implemented stand alone. This technique is used for wideband.

III. CONCLUSIONS

This paper is a review paper and various linearization methods are described for linearizing high power amplifiers. Linearization of amplifiers is very necessary as it is the main component of communication system. Linearizer increases the power capacity and efficiency of high power amplifiers for multi carrier and complex digital signals. The drawback of the feed-forward is that it is used when high linearity is required. Feedback linearization technique works well but it is used for limited bandwidth. In all linearization technique pre-distortion has several advantages as it is simple, used for both low and high linearity and digital signal processing can provide very high linearity.

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